African Journal of Agricultural Economics and Rural Development ISSN 2375-0693 Vol. 8 (1), pp. 001-007, January, 2020. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Economic assessment of seed-tuber practices of yam *Dioscorea cayenensis and Dioscorea rotundata* planting materials

Afio Zannou

Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, 02 BP 1621 Cotonou, Benin. E-mail: afiozannou@yahoo.com.

Accepted 03 October, 2019

Planting material from different tuber parts (proximal, medial, distal) of four yam (*Dioscorea cayenensis* and *Dioscorea rotundata*) varieties (Laboko, Gangni, Alakitcha, Gnanlabo) showed significant differ-ences in number of plants emerged and time of emergence. This result confirms the value of farmer's variety-specific handling of seed tubers. For three out of these four farmer varieties, there were significant differences in mean value of days after planting to emergence between parts of planting materials used. For all varieties, the proximal parts sprouted earlier than the medium parts and than the distal parts, and the loss was the highest for the distal parts. The rate of emergence is of economic importance in managing yam planting material by farmers. All tubers planted emerged for both the proximal part and the entire tuber of the second harvest. There was a highly significant difference between yield performances. The joint effect of variety and seed type was highly statistically significant in determining the yield obtained by yam farmers in Benin. The marginal benefit was the highest for the proximal part except for Laboko for which the highest benefit was obtained from the use of the second harvest seed-type. Laboko provided also the lowest and negative benefit for the distal part.

Key words: Farmer yam-seed practices, knowledge, rate of emergence, loss, productivity, profitability.

INTRODUCTION

Yam (*Dioscorea* spp.) forms a basic staple food for millions of people in West Africa, where it is eaten boiled or processed into various forms of flour and starchy pas-te. It is an ancient crop in Benin and deeply embedded in rural social life, associated with many traditional rituals. The crop also significantly contributes to rural food secu-rity. This security arises from crop diversity at farm level, which ensures a diversity of uses, and prolonged sea-sonal availability of food and income (Zannou et al., 2007). Benin is the fourth yam producer in the world after Nigeria, Ivory Coast and Ghana (FAO, 1996) . Despite earlier expectations that the crop might diminish in impor-tance, yam production in Benin increased from 680,000 metric tonnes in 1983 to 1,250,000 metric tonnes in 1995 (FAO, 1996). This production increase of 83% has been realized on an increased cultivated area of 63%, showing some limited degree of intensification.

White and yellow yams (*Dioscorea rotundata* and *Dioscorea cayenensis*) may have been first domesticated in the forest-savannah ecotone of West Africa (Terauchi et al., 1992; Hamon et al., 1995; Ramser et al., 1997; Tostain et al., 2003) . The germination and development of true seed of yam obtained from the aerial parts after polli-nation is infrequent. Some farmers also continue the practice of bringing in planting material from the wild to solve problems of decrease in yield and vigour of culti-vated varieties, or the loss or lack of planting mate-rials (Dumont and Vernier, 1997, 2000; Mignouna and Dansi, 2003; Vernier et al., 2004; Houndékon and Man-yong, 2004; Zannou et al., 2006).

Yam tubers exhibit dormancy which prolongs its stora-bility and maintains the food quality (Ile et al., 2006) . Yam farmers face many problems regarding the yam seed management. Several recent studies tried to exogenously influence this dormancy (Barker et al., 1999; Craufurd et al., 2001; Park et al., 2001; Horvath et al., 2003; Ile et al., 2006; Offei et al., 2006; Abdul Jaleel et al., 2007a; Pan-neerselvam et al., 2007); which technologies are still away from the resource – poor yam farmers of Benin. The preliminary survey of our diagnostic study (Zannou et al., 2004) has revealed the need to address the variety-specific ways of cutting the seed tubers to save on seed tuber costs or to enhance the seed tuber productivity. Yam growers in Benin practise cutting of seed tubers and use specific parts of the seed tubers as planting material. The reasons behind this may be associated with the sprouting capacity of the eyes present in the different sections of the seed tubers, but there is little research to prove this assumption to be true. The research questions were why do farmers in Benin use particular seed tuber parts as planting material and why are their practices of cutting the seed tubers different for different varieties?. The hypothesis here is that farmers are aware of the specific anatomy of the seed tubers from different varieties, know the physiological behaviour of varieties in response to cutting the seed tubers such as breaking of dormancy or breaking of apical dominance, and recognize the differences in agronomic performance of seed tuber pieces of specific varieties.

The specific objectives of the study were: (i) to experiment different parts of tubers as planting materials and the basic understanding that govern seed practices in yam diversity management in Benin, thus seeking, with farmers, to know how to optimize the performance of the planting material; (ii) and to assess the economic profitability of the seed tuber practices.

MATERIALS AND METHODS

Research site

This research has been conducted on the experimental site of Yagbo village in the district of Glazoué in the central part of Benin. This district lies between 7 and 10° northern latitude in the Guinea Sudan transition zone of Benin. The annual rainfall varies between 1100 and 1200 mm, and the average monthly temperature between 22 and 32.8°C. The natural vegetation is mainly tree savannah.

Materials

This research has been conducted jointly with farmers experimenters (a learning group) with whom the research constraints have been identified (Zannou et al., 2004). Traditional practice on planting material is based on using different parts of the tuber, very often the entire tuber from the second harvest for early maturing varieties and the proximal, middle, and distal part at first (and only) harvest for both early and late maturing varieties of *D. cayenensis* / *D. rotundata*. Seed-tubers from four different farmer-varieties (Laboko, Gangni, Alakitcha, and Gnanlabo) were selected, based on information given by farmers on those varieties. For the early-maturing varieties (Laboko and Gangni) there were four treatments: apical parts, middle parts, distal parts, and non-cut seed tubers, always using seed tubers from the second harvest. For the late- maturing varieties (Alakitcha and Gnanlabo) three treatments were applied: apical parts, middle parts, and distal parts of seed tubers taken from the only harvest that occurred. There were four repetitions of five heaps per variety for each experimental unit, resulting in 20 heaps per treatment per variety.

Data analysis

The generalized linear model of ANOVA has been used to analyze the yield results. The different factors considered in the yield performance were the variety, the seed type and the interaction variety × seed tuber type.

The assessment of the total production costs involved the variety-specific seed- tuber cost and the labour costs (land clearing, plan-ting, laying pad against sun hits, ploughing, weeding and harvest-ing) . Using the yield output representing the physical productivity, and considering the average variety-specific selling price, the aver-age gross revenue per heap was computed. The marginal farm-gate benefit was assessed as the difference between gross reve-nue per heap and the total production cost per heap.

RESULTS

Days after planting until emergence

For three out of the four varieties, there were significant differences in mean value of days after planting to emergence (DAP) between parts of planting materials used (Table 1). The proximal part and the entire tuber of a second harvest of early-maturing varieties showed the fastest emergence. For Laboko, the proximal part and the entire tuber emerged after 19 and 26 DAP respectively; the medium part sprouted after 40 DAP and the distal part after 47 DAP. For Gangni, the proximal part was the earliest while the distal part was the latest in emergence. For the two late maturing varieties, Alakitcha and Gnanlabo, the proximal part also emerged earlier than the medium and the distal parts.

Economic importance of the rate of emergence

The rate of emergence is of economic importance in managing yam planting material by farmers. All tubers planted emerged for both the proximal part and the entire tuber of the 2nd harvest (Figure 1). This result suggests that any of those planting types can be used for planting when available. Within the late-maturing varieties, all planted proximal parts of Gnanlabo emerged. For the four varieties, the loss was highest for the distal part: it was of 5% for Gnanlabo, 50% for Laboko, 65% for Gangni, and 85% for Alakitcha. All tubers used from the second harvest as entire tubers and from the proximal sections of Gangni and Laboko, and from the proximal sections of Gnanlabo sprouted.

Seed-tuber productivity

Be it the distal, medium or proximal part, there was a highly significant difference between the yield performances of yam varieties (Table 2). For the distal part, the highest mean yield value was obtained for Gangni (3.01 kg/heap) and the lowest one for Laboko (0.98 kg/heap). Also for the middle and proximal parts, the highest yield was obtained for Gangni and the lowest yield for Laboko. However, when the seed tubers came from the second harvest, Laboko yielded more than Gangni, but the difference was not statistically significant. As such, yam varieties' performance not only depended on the variety or genotype that had been planted, but also on the seed

Table 1. Number of days after planting until emergence for tubers from proximal, medium, distal parts and tubers of second harvest.

Variety-types	Farmer-variety	Parts	N	Mean of DAP until emergence	S.E. of mean	F
Early maturing	Laboko	Proximal	20	18.7	1.49	42.09***
		Medium	11	39.5	2.37	
		Distal	10	47.3	1.28	
		Entire tuber of 2nd harvest	20	26.2	1.97	
	Gangni	Proximal	20	24.4	2.12	10.87***
		Medium	11	39.3	1.91	
		Distal	7	42.7	2.57	
		Entire tuber of 2nd harvest	20	28.9	2.33	
Late maturing	Alakitcha	Proximal	13	41.5	2.9	0.73
		Medium	6	45.0	2.2	
		Distal	3	47.3	0.9	
	Gnanlabo	Proximal	20	16.1	2.1	29.46***
		Medium	19	35.8	2.5	
		Distal	19	38.3	2.2	

Source: research findings; level of significance: ***: 1%

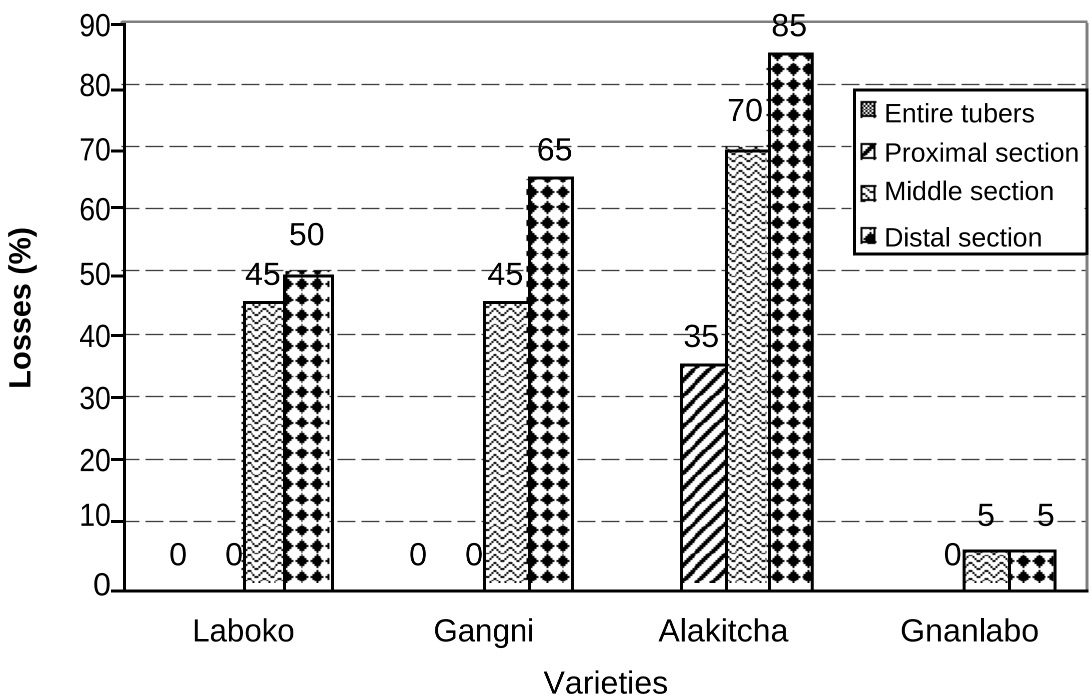

Figure 1. Losses in terms of non-emergence of planted materials submitted to different seed-section practices for four contrasting varieties. Note that the treatment “entire tubers” was not present for the late cultivars Alakitcha and Gnanlabo. Source: research findings.

tuber material that was used. Using the generalized linear model of ANOVA on the variety, seed type and interaction variety × seed tuber type, Table 3 reveals that the joint effect of variety and seed type was highly statistically significant in determining the yield obtained by yam farmers in Benin.

Table 2. One-way analysis of variance of yield performance per variety for each seed-type (kg/heap).

	Distal			Middle			Proximal			2nd harvest		
Source of variation	**D.F.**	**MS**	**F**	**D.F.**	**MS**	**F**	**D.F.**	**MS**	**F**	**D.F.**	**MS**	**F**
Variety	3	11.99	15.39***	3	13.08	9.90***	3	16.95	8.19***	1	2.28	1.52
Model	3	11.99		3	13.08		3	16.95		1	2.28	
Error	54	0.78		43	1.32		63	2.07				
R-square		0.46			0.38			0.28			0.05	
	Mean tuber yield (kg/heap) per variety and per seed-type											
	Mean		**SE**	**Mean**		**SE**	**Mean**		**SE**	**Mean**		**SE**
Gangni	3.01 a		0.16	3.77 a		0.40	4.08 a		0.43	1.90		0.31
Laboko	0.98 c		0.16	1.40 b		0.15	1.79 b		0.32	2.43		0.30
Alakitcha	2.11 b		0.35	1.79 b		0.34	2.90 b		0.38	-		-
Gnanlabo	1.32 c		0.21	1.95 b		0.21	2.33 b		0.24	-		-
Overall mean		1.93			2.28			2.82			2.19	

Source: research findings. Figures followed by a same letter are not significantly different at the level of 5%.

Table 3. GLM-ANOVA of yield performance depending on the variety and the seed-type.

Source of variation	DF	Mean square	F
Variety	4	23.45	16.92***
Seed type	3	9.29	6.70***
Variety × seed type	9	5.63	4.06***
Model	16	10.35	7.47***
Pooled error	224	1.39	
R-square	0.35		

Source: research findings; Level of significance: ***:1%.

Marginal benefits

The analysis of the profitability revealed that for distal, middle and proximal parts, the variety Gangni got the highest marginal benefit values, 131, 238 and 268 fcfa/heap, respectively. The lowest values were obtained on Lakobo for the distal part, and on Alakitcha for the middle and proximal parts (Table 4). While the seed-tuber used as planting material is a second harvest-type, the marginal benefit from Laboko is higher than the one of Gangni, 262 and 50 fcfa/heap respectively.

DISCUSSION

Farmers' seed practices and knowledge

The reasons why farmers use different specific parts of tubers as planting materials depend on the variety in question as reported by farmers (Table 5). Farmers handle the seed tubers of early-maturing and late-maturing varieties differently, because the seed tubers are produced in a differ-ent way. In early-maturing varieties, tubers for consumption or sale are harvested first. The plant then produces new tubers which are used as planting tubers for the next cropping season. This is called "double harvest". The first harvest is done at the physiological maturity of the tubers, a stage at which the tuber reaches its maximum develop-

Table 4. Marginal farm-gate benefits.

Seed type	Farmer variety	Mean yield (kg/heap) (1)	Average variety selling price (Fcfa/ kg) (2)	Gross Revenue (Fcfa/heap) (1) x (2)=(3)	Total production cost (Fcfa/heap) (4)	Marginal farmgate benefit (F/heap) (5)=(3)-(4)
Distal	Gangni	3.01	100	301	140	161
	Laboko	0.98	190	186	200	-14
	Alakitcha	2.11	90	190	140	50
	Gnanlabo	1.32	150	198	190	8
Middle	Gangni	3.77	100	377	140	237
	Laboko	1.40	190	266	200	66
	Alakitcha	1.79	90	161	140	21
	Gnanlabo	1.95	150	293	190	103
Proximal	Gangni	4.08	100	408	140	268
	Laboko	1.79	190	340	200	140
	Alakitcha	2.90	90	261	140	121
	Gnanlabo	2.33	150	350	190	160
2nd harvest	Gangni	1.90	100	190	140	50
	Laboko	2.43	190	462	200	262

Source: research findings.

Table 5. Farmers' seed practices and knowledge.

Variety-type	Farmer-variety	Farmers' seed practices and knowledge
Early-maturing	Laboko	Laboko is an early maturing variety. Often farmers do not use a sectioned tuber as it quickly rots. By experience, farmers do not plant the distal part of Laboko because it never or rarely sprouts. The vigour of a non-fractioned tuber is higher than the one from which the distal part has been removed.
	Gangni	Gangni is an early maturing variety for which the second harvest is often used for seed. Farmers have the opinion that the tuber of Gangni can be sectioned in case the proximal part is used for planting; but the distal part sprouts very slowly.
Late-maturing	Alakitcha	Alakitcha is a late maturing variety. Only its proximal part is used as planting material by farmers.
	Gnanlabo	Gnanlabo is a late maturing variety. Farmers mentioned that any part of Gnanlabo can sprout if they prepare the tuber properly before planting. However, farmers often use an entire tuber as tubers from Gnanlabo are not very big.

Source: research findings.

ment in the soil and can be harvested and processed for food. At this stage, the yam plant is still alive and green and the crop is maintained. The second harvest takes place at the complete senescence of the plant. Tubers at that time are much smaller than the tubers harvested at the first harvest. The decision, what proportion of the total field will be used for double harvesting is taken before or at physiological maturity. Crops which are projected to be used for this double harvesting technique will be planted with whole tubers and cutting of their progeny tubers is not done, because mostly of the risk of loss.

Late-maturing varieties, usually called "single harvest" varieties, are only harvested once. Examples are the varieties Gnanlabo or Alakitcha. One of the characteristics of these late-maturing varieties is that the yield is composed of several tubers differing in size. The large tubers are used for consumption or sale and the small ones are used for planting the next cropping season. A single harvest is undertaken at the complete senescence of the plant. The relatively big seed tubers can be cut, in a way depending on size. There is a desired seed tuber size for planting, as smaller sizes will have lower vigour as planting material.

Implications of farmer's know-how and of the experimentation

Double harvesting practices appear to reflect an agro-physiological principle known and respected by farmers concerning early-maturing varieties, and the need to avoid second crop seed tubers at planting time because use of other parts than the whole tuber from the 2nd harvest as planting material usually results in high losses, that is, non-sprouting of the tubers after planting, and consequently high economic loss and thus undermines food insecurity. In farmers' practices, there are some varieties of late ones whose all parts can sprout (Gnanlabo) and others for which only the proximal part is used by farmers as planting materials (Alakitcha). Experimentation revealed a gradient along the tuber in its potential for sprouting. The proximal part of most varieties has a high sprouting potential, while the distal part has the lowest potential. Experimentation in real farming conditions revealed that the proportion of non- emerged plants after planting was highest and yields the lowest when the distal part was used as planting material. However there was some variation among varieties. The results suggest that there could be a complex genetic – physiological property governing the sprouting ability of each fragment of the tuber. In addition, as revealed by other studies, along the tuber, there could a gradient of earliness in sprouting, in the availability of nutrient reserves and in the viability which decreases from the proximal to the distal part (Kossou, 1990). Sprouting ability and biochemical constituents differ with the physiological regions and are higher in apical than basal regions of *D. rotundata* (Abdul Jaleel et al., 2007b; Abdul Jaleel et al., 2008) . On *D. cayenensis* cultivars, the biochemical properties and active starch content are significantly higher in middle-derived tubers than tail-derived setts (Wheatley et al., 2002). Also, the emergence and yield are significantly influenced by both the sprouting state at planting and the origin of a sett with respect to its position on the mother tuber (Tschannen et al., 2005), conducting them to suggest that limited resources should be to directed to apical setts and sprouted which have the highest yield potential for *D. cayenensis* and *D. rotundata* cultuvars. This experiment showed four different cases of seed tubers used by farmers. One is the case of the variety Laboko for which the use of non-cut tuber of the second harvest and a second case is the one of Alakitcha for which the proximal part is used by farmers. Developing a seed tuber market should acknowledge this fact and only farmers who hold this know-how are in position to apply it on their own planting materials.

REFERENCES

Abdul Jaleel C, Gopi R, Manivannan P, Kishorekumar A, Gomathinayagam M, Panneerselvam R. (2007b). Changes in biochemical constituents and induction of early sprouting by triadimefon treatment in white yam (*Dioscorea rotundata* Poir.) tubers during storage. J. Zhejiang Univ. Sci. B 8(4):283-288.

Abdul Jaleel C, Gopi R, Panneerselvam R (2008). Biochemical alterations in white yam (*Dioscorea rotundata* Poir.) under triazole fungicides: impacts on tuber quality. Czech J. Food Sci. 26(4):298-307.

Abdul Jaleel C, Kishorekumar A, Manivannan P, Sankar B, Gomathinayagam M, Gopi R, Somasundaram R, Panneerselvam R (2007a). Alterations in carbohydrate metabolism and enhancement in tuber production in white yam (*Dioscorea rotundata* Poir.) under triadimefon and hexaconazole applications. Plant Growth Regul. 53:7-16.

Barker DJ, Keatinge JDH, Asiedu R (1999). Yam dormancy: potential mechanisms for its manipulation. Trop. Sci. 39:168–177.

Craufurd PQ, Summerfield RJ, Asiedu R, Vara Prasad PV (2001). Dormancy in yams. Exp. Agric. 37:147-181.

Dumont R, Vernier P (1997). La domestication des ignames (*D. cayenensis - D. rotundata*) chez l'ethnie Bariba du Bénin, in: Actes du colloque Gestion des ressources génétiques des plantes en Afrique des Savanes, Bamako, Mali, 24-28 Février 1997, IER, BRG, Solagral, pp. 47-54.

Dumont R, Vernier P (2000). Domestication of yams (*Dioscorea cayenensis - rotundata*) within the Bariba ethnic group in Benin. Outl. Agric. 29:137–142.

FAO (1996). FAOSTAT, December 1996. Rome, Italy.

Hamon P, Dumont R, Zoundjihékpon J, Tio-Touré B, Hamon S (1995). Les ignames sauvages d'Afrique de l'Ouest. Caractéristiques morphologiques. Wild yam in West Africa. Morphological characteristics. Ed. Orstom.

Horvath DP, Anderson JV, Chao WS, Foley ME (2003). Knowing when to grow: signals regulating bud dormancy. Trends Plant Sci. 8(11):534-540.

Houndékon AV, Manyong VM (2004). Indigenous knowledge of wild yams in West Africa: Experience from Benin Republic. In: Sperling et al. (eds) Participatory Plant Breeding and Participatory Plant Genetic Resource Enhancement. An Africa-wide exchange of experiences / Sélection participative et gestion participative des resources génétiques en Afrique. Echanges d'expériences. Proceedings of a workshop held on M'bé, Ivory Coast, May 7 – May 10, 2001 / Actes de l'atelier de M'bé, Côte d'Ivoire, 7 Mai – 10 Mai, 2001. Published by CGIAR Program for Participatory Research and Gender Analysis (PGRA), Colombia, pp. 170-177.

Ile EI, Craufurd PQ, Battey NH, Asiedu R (2006). Phases of dormancy in yam tubers (*Dioscorea rotundata*). An. Bot. 97:497-504

Kossou DK (1990). Evaluation de pratiques culturales relatives á la production de semenceaux et de tubercules d'igname (*Dioscorea rotundata*) au Bénin. Tropicultura 8(2):69-73.

Mignouna HD, Dansi A (2003). Yam (*Dioscorea ssp.*) domestication by Nago and Fon ethnic groups in Benin. Gen. Res. Crop. Evol. 50:512-528.

Offei SK, Ofosu-Anim, Teiko J, Yamaki S (2006). Induction of multiple tuberization in yam (*Dioscorea* spp.) using Ethephon. Int. J. Agric. Biol. 8(1):73-75.

Panneerselvam R, Abdul Jaleel C, Somasundaram R, Sridharan R, Gomathinayagam M (2007). Carbohydrate metabolism in *Dioscorea esculenta* (Lour.) Burk. tubers and *Curcuma longa* L. rhizomes during two phases of dormancy. Coll. Surf. B: Biointerf. 59:59-66.

Park BJ, Onjo M, Tominaga S, Hayashi M (2001). The relationship between plant hormones and dormancy of tuber in yams (*Dioscorea* spp.). Japan. J. Trop. Agric. 44:29–30.

Ramser J, Weising K, Lopez-Peralta C, Terhalle W, Terauchi R, Kahl G (1997). Molecular marker-based taxonomy and phylogeny of Guinea yam (*Dioscorea rotundata-D. cayenensis*). Genome 40: 903-915.

Terauchi R, Chikaleke VA, Thottappilly G, Hahn SK (1992). Origin and phylogeny of Guinea yam as revealed by RFLP analysis of chloroplast DNA and nuclear ribosomal DNA. Theo. Appl. Genet. 83:743–751.

Tostain S, Okry FK, Baco NM, Mongbo RL, Agbangla C, Daïnou O (2003). La domestication des ignames *Dioscorea abyssinica* dans les sous-préfectures de Sinendé et de Bantè au Bénin (Afrique de l'Ouest). Ann. Sci. Agron. Bénin 4(1):33-54.

Tschannen AB, Escher F, Stamp P (2005). Post-harvest treatment of seed tubers with gibberellic acid and field performance of yam (*Dioscorea cayenensis-rotundata*) in Ivory Coast. Exp. Agric. 41(2):175-186.

Vernier P, Orkwor GC, Dossou AR (2004). An overview of the farmer's knowledge of yam domestication in Benin and Nigeria. In: Sperling et al. (eds) Participatory Plant Breeding and Participatory Plant Genetic Resource Enhancement. An Africa-wide exchange of experiences / Sélection participative et gestion participative des resources génétiques en Afrique. Echanges d'expériences. Proceedings of a workshop held on M'bé, Ivory Coast, May 7 – May 10, 2001 / Actes de l'atelier de M'bé, Côte d'Ivoire, 7 Mai – 10 Mai, 2001. published by CGIAR Program for Participatory Research and Gender Analysis (PGRA), Colombia, pp. 280-290.

Wheatley AO, Iyare OA, Asemota HN (2002). Effect of section of yam (*Dioscorea cayenensis*) tuber used in minisett on the biochemical properties of the resultant tuber. J. Sci. Food Agric. 82(13):1579-1583.

Zannou A, Ahanchédé A, Struik PC, Richards P, Zoundjihékpon J, Tossou R, Vodouhè S (2004). Yam and cowpea diversity management by farmers in the guinea-sudan transition zone of Benin, NJAS – Wag. J. Life Sci. 52 (3-4):393-420.

Zannou A, Richards P, Struik PC (2006). Knowledge on yam variety development: insights from farmers' and researchers' practices. Know. Manage. Dev. J. 2(3):30-39.

Zannou A, Tossou RC, Vodouhè S, Richards P, Struik PC, Zoundjihékpon J, Ahanchédé A, Agbo V (2007). Socio-cultural factors influencing and maintaining yam and cowpea diversity in Benin. Int. J. Agric. Sust. 5(2-3):140-160.